



Reactive Chemicals Hazard Investigation

Chemical Safety and Hazard Investigation Board

Investigation Team:

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Joint EFCOG/DOE

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Outline

- CSB Mission
- Reactive Chemicals Hazard Investigation Background
- Impact of Reactive Chemical Incidents
- Reactive Chemicals Incident Case Histories
- Reactive Chemical Incident Data



CSB Mission

Enhance the health and safety of workers and the public, and protect the environment by:

- Uncovering causes of accidental chemical releases
- Using findings and supporting research to promote preventive actions by both the private and public sectors



Mission Objectives

- Investigate carefully selected major incidents involving hazardous chemicals at fixed facilities
- Produce high quality and timely investigation reports identifying root and contributing causes
- Conduct hazard, safety, and data studies designed to complement investigation report and recommendation activities
- Issues well-reasoned and precisely targeted recommendations
- Conduct effective advocacy activity for recommendations



CSB Unique Authorities

- Not bound by regulatory definitions of chemicals or scope
- Performs root cause investigations
- Makes recommendations to Industry, Associations, or Other Agencies



Morton Incident Review (9 Injured)

KEY ISSUES:

Internal Hazard Communication

Reactive Hazard Management

Process Safety Management

FINAL REPORT:

August 2000



Morton International, Inc.,
Paterson, NJ (4/8/98)



Hazard Investigation Objectives

- To examine the hypothesis that there are too many severe reactive chemical incidents.
- To determine the causes and impacts of reactive chemical incidents.
- To analyze existing reactive chemicals hazard management systems within the chemical industry (small, medium and large companies).
 - » Policies
 - » Practices
 - » Reactivity research capability
 - » Testing Program
 - » Process Engineering



Hazard Investigation Objectives (cont.)

- To examine how OSHA/EPA are currently addressing reactive chemical hazards.
- To consider alternatives to using NFPA instability ratings for OSHA PSM application.
- Likely to develop recommendations to reduce the number and impacts of reactive chemical incidents.



Reactive Chemical Incident

Definition - A reactive chemical incident is a sudden event involving an uncontrolled chemical reaction with significant increases in temperature, pressure, and/or gas evolution that has the potential to or has caused serious harm to people, property or the environment.

- Focus on events that have actually caused significant harm
- Includes chemical manufacturing from raw material storage, through chemical processing to product storage
- Bulk storage and handling facilities included
- Excludes transportation, pipelines, labs, minerals extraction, mining, explosives manufacturing, pyrotechnic manufacturing, or military uses
- Not intended to include simple combustion of fuel/air mixture



Data Sources

- Regulatory – OSHA, EPA ARIP, EPA RMP
- Industry Associations – Chlorine Institute
- Professional Societies – IChemE, AIChE
- Insurance Industry – Marsh McLennan
- Notification Database – NRC
- News/Current Events Publications
- Topical Journals and Texts
- UK/HSE – Major Hazard Incident Data
- Chemical Safety Board – CIRC
- Safety/Loss Prevention Texts (various)
- Brethericks - Reactive Chemical Hazards
- USE DOE – Chemical Safety Reports
- NFPA-Fire Incident Data Organization (FIDO)
- USFA - National Fire Incident Reporting Syst.
- EU/EC – Major Accident Reporting System
- TNO Process Safety – FACTS
- NTSB Hazardous Material Incident Reports
- Census of Fatal Occupational Injuries (CFOI)
- Awareness and Preparedness for Emergencies at Local Level (APELL)
- EPA's Acute Hazardous Events Database (Considered Only)
- Hazardous Substances Emergency Events Surveillance (HSEES) - (Considered Only)
- Mary Kay O'Connor PSC – (Considered Only)
- EU/EC Community Documentation Centre on Industrial Risk (Considered Only)
- American Chemistry Council - Process Safety Measurement System (Considered Only)
- API's Process Safety Database (Considered Only)
- CCPS Incident Database (NO ACCESS)



Impact of Reactive Incidents

- 167 domestic incidents (1980 – 2001) in CSB data
- 108 fatalities in 48 incidents
- An average of 3 fatal incidents occur each year ^[1]
- An average of 9 injury-related incidents occur each year ^[1]
- No clear trends in number of events over past 10 years

[1] Since 1991



Consequences

- Primary impact is onsite, however reactive incidents can impact the public, and this has been shown to happen in approximately 30% of incidents.
- “Public impact” defined as known injury, evacuation, or shelter-in-place.
- Consequence of reactive incidents can include:
 - Fire/explosion,
 - Toxic Gas Release,
 - Hazardous Liquid Spill



Consequences

- Reactive incidents can result in severe business impacts including property loss

| <u>Property Damage Loss Range</u> | <u>Number of Incidents^[1]</u> |
|---------------------------------------|--|
| \$ 10 MM - \$100 MM | 12 + |
| > \$100 MM | 4 |

[1] Data is intended to be illustrative, not comprehensive



Severe Reactive Incidents

| | <u>Location</u> | <u>Date</u> | <u>Fatalities</u> |
|----|-------------------------|-------------|-------------------|
| 1 | Channelview TX | 7/5/90 | 17 |
| 2 | Charleston SC | 6/17/91 | 9 |
| 3 | Sterlington LA | 5/1/91 | 8 |
| 4 | Lodi NJ | 4/21/95 | 5 |
| 5 | Allentown PA | 2/19/99 | 5 |
| 6 | Port Neal IA | 12/13/94 | 4 |
| 7 | Auburn IN | 6/28/88 | 4 |
| 8 | Gulfport MS | 6/2/82 | 3 |
| 9 | Barceloneta Puerto Rico | 6/12/86 | 3 |
| 10 | Belpre OH | 5/27/94 | 3 |
| 11 | West Helena AR | 5/8/97 | <u>3</u> |
| | | Total | 64 |



Other Notable Recent Incidents

| <u>Location</u> | <u>Date</u> | |
|-----------------|-------------|------------------|
| Pasadena TX | 6/23/99 | 2 Fatalities |
| Bucks AL | 9/4/99 | 1 Fatality |
| Alamogordo NM | 8/6/99 | 1 Fatality |
| Whitehall MI | 6/4/99 | 1 Fatality |
| Columbus OH | 9/10/97 | 1 Fatality |
| Pasadena TX | 3/27/00 | 1 Fatality |
| Patterson NJ | 4/8 /98 | 9 Injured |
| Baltimore, MD | 10/13/98 | 5 Injured |
| Deer Park TX | 3/29/00 | > 1000 Evacuated |



April 21, 1995 Napp Technologies Lodi, NJ



- Five Fatalities
- Approximately 300 evacuated
- Significant damage to the facility and surrounding businesses

Ed Hill, *The Record*
Rich Gigli, *The Record*



April 21, 1995
Napp Technologies
Lodi, NJ

Incident Description

- Napp was performing a toll blending operation
- The product was a commercial chemical mixture – ACR9031, a gold precipitating agent comprised of sodium hydrosulfite, aluminum powder, potassium carbonate, and benzaldehyde
- The most likely cause of the incident was the inadvertent introduction of water / heat into water reactive materials



April 21, 1995
Napp Technologies
Lodi, NJ

Outcomes of the Napp Incident

- Raised questions regarding the use of the NFPA instability system for regulating reactives
- EPA/OSHA Joint Investigation recommended
 - Review the PSM and RMP lists to determine how reactives should be handled
 - Review the role of the MSDS in process safety information
 - » Don't use MSDS's beyond their intended guidelines
 - » Understand the limitations of MSDS's
- Unions petitioned OSHA for an emergency revision of standards on process safety management and emergency response



May 8, 1997
Bartlo Packaging Inc.
West Helena, AR



- Three Fatalities
- 17 Injuries
- Significant Facility Damage
- Hundreds Evacuated
- Mississippi River and Major Roads closed to traffic for 12 hours

Rick McFarland, *Arkansas Democrat-Gazette*



May 8, 1997
Bartlo Packaging, Inc.
West Helena, AR
Incident Description

- Bartlo Packaging, Inc. (BPS) was an agricultural packaging facility
- Under tolling agreements, BPS was repackaging the pesticide Azinphosmethyl (AZM) 50W
- The most likely cause of the incident was decomposition of a bulk sack containing AZM 50W which had been placed against or close to a hot compressor discharge pipe. The heat from the pipe caused the material to decompose and give off flammable vapors which resulted in an explosion.



June 4, 1999 Whitehall Leather Company Whitehall, MI



- One fatality
- One injury
- 11 employees evacuated

Lisa Medendorp, *The Chronicle*



June 4, 1999
Whitehall Leather Company
Whitehall, MI
Incident Description

- Whitehall Leather Company operated a leathery tannery in Whitehall, Michigan
- The accident resulted from a truck load of hydrosulfide solution being transferred into a tank of ferrous sulfate solution. The two substances reacted to produce hydrogen sulfide which is a poisonous gas.



February 19, 1999 Concept Sciences, Inc. Allentown, PA



- Five Fatalities
- Multiple Injuries
- Extensive damage to the building and surrounding buildings

Tom Volk, *The Morning Call*



February 19, 1999
Concept Sciences, Inc.
Allentown, PA
Incident Description

- Concept sciences was distilling an aqueous solution of hydroxylamine and potassium sulfate
- The chemical involved in the explosion, hydroxylamine, is capable of rapid exothermic decomposition which can lead to explosive decomposition when confined.
- The explosion occurred while Concept Sciences was processing the first batch of material
- The process was in the final stage designed to distill off water from hydroxylamine solution to achieve 50% composition. Decomposition of concentrated hydroxylamine resulted in the explosion.



March 13, 2001
BP Amoco
Augusta, GA



- Three fatalities
- Localized unit damage



March 13, 2001

BP Amoco

Augusta, GA

Incident Description

- BP Amoco was producing Amodel, a nylon polymer
- Material collected in a polymer catch tank decomposed yielding gas which generated pressure
- Three employees were in the process of opening the catch tank when the pressure was released
- Subsequent damage resulted in a second explosion and fire several minutes later



March 13, 2001

BP Amoco

Augusta, GA

Root and Contributing Causes

- CSB is conducting a full root cause investigation of this incident
- The investigation has confirmed that this is a reactive chemical incident
- Root cause information will be detailed in the full CSB report



Industry Profile

- Reactive incidents are not unique to the chemical manufacturing industry
- Bulk consumers/handlers of chemicals represent a significant portion of the problem.

| <u>Type of Facility</u> | <u>Percent of Incidents</u> |
|-----------------------------------|-----------------------------|
| Chemical Manufacturing | 60% + |
| Storage, Handling, Consumer Sites | Nearly 40% |



Profile of Reactive Incidents

- Reactive incidents occur in many different types of equipment.
 - 25% occur in chemical reactor vessels
 - 22% occur in storage equipment



Profile of Reactive Incidents

- The problem is represented by the diverse nature of Reactive Chemistry
 - Decomposition reactions
 - Acid/Base reactions
 - Water Reactive
 - Polymerization reactions
 - Oxidation reactions
 - Decomposition initiated by another reaction
 - Other (6 categories)
- The vast majority of reactive incidents involve known chemistry (90+%)



Profile of Reactive Incidents

- There is a wide diversity of chemicals and chemical classes that can exhibit reactive chemistry.
- It is difficult to focus on any one/few classes of chemicals.
 - Acids
 - Monomers
 - Oxidizers
 - Water
 - Organic Peroxides
 - Bases
 - Inorganic/Metals
 - Hypochlorites
 - Others (38 Classifications)



Profile of Reactive Incidents

- OSHA's PSM standard uses the NFPA's instability rating system to classify reactive chemicals
- A large percentage of incidents involve chemicals that are minimal reactivity hazards as per NFPA hazard rating systems and NFPA publications.
- Of the 167 incidents,
 - Approximately 88% involved chemicals which were not rated as NFPA 3's or 4's
 - Less than 50% involved chemicals rated as NFPA 1, 2, 3, or 4.



Common Causes

- Inadvertent mixing of incompatible chemicals represents a sizable portion of the reactive problem.
 - Nearly 40 % of incidents
- The classic Thermal Runaway still represents a smaller, but significant portion of the reactive problem.
 - Nearly 25% of incidents



Underlying Causes

- Underlying Cause information found in only about 20% of data
- Most reactive incidents (nearly 60% where information available) occur due to underlying failures to identify chemistry hazards and/or conduct an adequate Process Hazard Evaluation.
- Examples:
 - Hazard Identification
 - » West Helena AR 5/8/97
 - Process Hazard Evaluation
 - » Lodi NJ 4/21/95
 - » Baltimore MD 12/13/98 (during Management of Change)



Underlying Causes

- Many reactive incidents occur due to inadequate procedures for safe processing, storage, and/or handling of reactive chemicals
- Nearly 50% where information available
- Examples:
 - Whitehall, MI 6/4/99
 - West Helena, AR 5/8/97
 - Allentown, PA 2/19/99



Regulatory Aspects

- CSB determined if the chemicals involved in the 167 incidents were covered by PSM or RMP
- Analysis was limited by insufficient knowledge of chemical concentrations, quantities, or other chemicals in the same process
- Approximately half of the chemicals involved in the 167 incidents are not currently covered by PSM or RMP.



*The problem is not reactive
chemicals,
it's reactive chemistry.*